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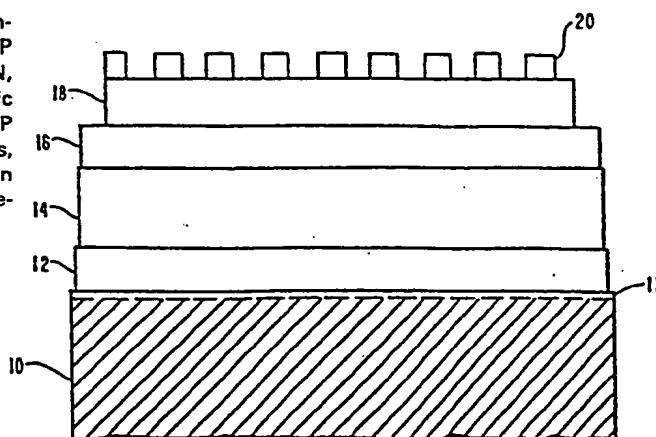
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(54) A method for sputtering a pin or nip amorphous silicon semi-conductor device having partially crystallised P and N-layers.

(57) A high efficiency amorphous silicon PIN or NIP semiconductor device having partially crystallised (microcrystalline) P and N layers is constructed by the sequential sputtering of N, I and P layers and at least one semi-transparent ohmic electrode. The method of construction produces a PIN or NIP device, exhibiting enhanced electrical and optical properties, improved physical integrity, and facilitates the preparation in a singular vacuum system and vacuum pump down procedure.



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FIG. I

1

2 The present invention relates to hydro-
3 genated amorphous silicon and more particularly to a
4 method for reactively sputtering a PIN amorphous sili-
5 con semiconductor device having partially crystallized
6 P and N layers.

7 Amorphous silicon has been used in a number
8 of semiconductor devices, the most promising of which
9 is the PIN structure. Such devices were first fabri-
10 cated by the method of glow discharge decomposition of
11 silane and described in a technical publication by
12 D. E. Carlson, J. Non-Crystalline, 35-36, (1980)
13 p. 707. The P and N layers in this method are
14 deposited by mixing approximately 1 to 2% of B_2H_6 or
15 PH_3 in the silane discharge. The principal deficiency
16 of this device, as noted by Carlson, is that the P-
17 layer which forms the major semiconductor junction
18 with the I-layer, is both poorly conductive and
19 absorbs the incident light energy without signifi-
20 cantly contributing to the collection of photogener-
21 ated charge carriers in the device. Because the
22 N-layer absorbs much less light than the P-layer,
23 Carlson has shown that illumination from the N-side
24 leads to higher solar cell efficiency.

25 A further improvement to the efficiency of
26 this device has been described in a technical publica-
27 tion by Y. Uchida et al., Japanese Journal of Applied
28 Physics, 21, (1982) p. L586. These authors fabricated
29 the N-layer by glow discharge decomposition of a mix-
30 ture of $SiH_4-H_2-PH_3$ and high power in the discharge.
31 Under these conditions, they claim that the N-layer is

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1 partially crystallized (microcrystalline) and there-
2 fore it is both highly conductive and highly trans-
3 parent in the visible part of the spectrum. This type
4 of N-layer is ideal as a "window" material and leads
5 to a 13% improvement in the short-circuit current of
6 the solar cell. The devices reported by Uchida have
7 the configuration stainless steel/PIN/ITO with the P
8 and I-layers being amorphous and the N-layer being
9 microcrystalline.

10 PIN semiconductor devices have also been
11 fabricated by the method of reactive sputtering and
12 described in a technical publication by T. D.
13 Moustakas and R. Friedman, Appl. Phys. Lett. 40,
14 (1982) p. 515. The I-layer of these devices was fabri-
15 cated by sputtering from an undoped silicon target in
16 an atmosphere of Argon containing 10-20% H₂. The P and
17 N-layers were fabricated by adding approximately 0.1
18 to 1% of B₂H₆ or PH₃ in the Ar-H₂ discharge. The
19 hydrogen content for the "window" (P-layer) was
20 increased to approximately 20 to 40% in order to im-
21 prove its transparency to visible light. All three
22 layers (P, I, N) if this device are amorphous.

23 In view of the improvements of the solar
24 cell efficiency of PIN devices produced by glow dis-
25 charge decomposition of silane employing a micro-
26 crystalline N-contact as a "window" layer, it is
27 important to fabricate such devices by the method of
28 RF sputtering.

29

30 The invention is directed to a method for
31 depositing by RF sputtering an amorphous PIN Semi-
32 conductor device, having the "window" (P or N) or both

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1 contacts deposited under conditions which lead to
2 partially crystallized (microcrystalline) material.
3 The method of the present invention shall be illus-
4 trated and described with respect to a PIN device. It
5 is to be understood, however, that the method of the
6 present invention applies equally well to a NIP
7 device.

8 A microcrystalline N-layer is deposited by
9 RF sputtering from an undoped silicon target in an
10 atmosphere containing hydrogen, argon and phosphine at
11 a total pressure larger than 20 mTorr with $H_2/Ar \gg 1$
12 and phosphine content approximately 0.1 to 1 vol % of the
13 argon content. The power in the discharge is adjusted
14 to lead to DC bias target voltage of between -800 to
15 -2000 volts and the substrate temperature to between
16 200 to 400°C. An intrinsic layer is also reactively
17 sputtered from an undoped target in an atmosphere of 5
18 to 15 mTorr of argon containing 10 to 20 vol % hydrogen.
19 The target voltage and the substrate temperature are
20 the same as during the deposition of the N-layer. This
21 I-layer is amorphous. A microcrystalline P-layer is
22 reactively sputtered from an undoped silicon target in
23 an atmosphere containing hydrogen, argon and diborane
24 at a total pressure larger than 20 mTorr with $H_2/Ar \gg 1$
25 and diborane content approximately 0.1 to 1 vol % of the
26 argon content. The target voltage and the substrate
27 temperature vary in the same range as those of the N
28 and I-layers. The contact (P or N) which is deposited
29 on the top of the I-layer is preferably deposited at
30 lower target voltage (-800 volts) in order to avoid
31 surface damage of the I-layer. [The three layers are
32 deposited sequentially in three interlocked chambers
33 in order to avoid cross contamination between the
34 layers. If they are deposited in the same chamber the
35 chamber has to be purged and sputtercleaned between

1 the first doped and the intrinsic layer.] Transparent
2 electrodes and metallic grids are also sputter de-
3 posited which permits the entire deposition to be
4 accomplished in one sputtering apparatus and in one
5 vacuum pump-down. When the P and N layers are fabri-
6 cated in microcrystalline form, the PIN solar cells
7 have an open circuit voltage of about 0.1 to 0.20 V
8 higher than entirely amorphous PIN solar cells and 10
9 to 20% higher short circuit current due to the better
10 blue response of these solar cells.

11 In the drawings:

12 Figure 1 shows a greatly enlarged side view
13 of a semi-conductor device constructed in accordance
14 with the teaching of the present invention.

15 Figure 2 shows the I-V characteristics of a
16 sputtered PIN solar cell having microcrystalline P and
17 N layers.

18 Figure 3 shows the increase in the collec-
19 tion efficiency in the blue portion of the spectrum of
20 a PIN Cell by using a microcrystalline P-layer for the
21 front contact and a microcrystalline N-layer as the
22 rear contact compared to one having amorphous P-layer
23 and N-layer.

24

25 The sputtered amorphous silicon PIN device
26 of the present invention, as illustrated in Figure 1,
27 includes a substrate 10 which generally comprises a
28 physically supportive substrate for the overlying
29 sputter deposited layers. Substrate 10 includes a

1 major area coating surface which is substantially free
2 from voids or protrusions of the order (in size) of
3 the thickness of the overlying layers to avoid pin
4 holes therethrough.

5 In one embodiment, substrate 10 may comprise
6 a non-electroconductive material such as glass or
7 ceramic for which an overlying layer of an electro-
8 conductive material 11 is required. Alternately, sub-
9 state 10 may comprise a metal concurrently serving as
10 a supportive substrate and an electrode contact to the
11 overlying layers. In either instance, the coating
12 surface of the substrate is thoroughly cleaned to
13 remove unwanted contamination of the coating surface.
14 In a preferred embodiment, electrode 10 comprises a
15 metal known to form an ohmic contact to N-doped sili-
16 con such as molybdenum or stainless steel for example.
17 In the case where substate 10 comprises a nonelectro-
18 conductive material it is preferred that layer 11
19 comprise a layer of metal known to form an ohmic con-
20 tact to N-doped microcrystalline silicon; examples are
21 molybdenum or chromium thin films of approximately
22 1,000 to 2,000 Å thick or a transparent conductive
23 oxide such as indium tin oxide (ITO), SnO₂ or cadmium stannate
24 approximately 1000 Å thick.

25 The substrates are fastened to the anode
26 electrode of a conventional RF diode sputtering unit
27 which is adapted to provide controlled partial pres-
28 sures of hydrogen, argon, phosphine and diborane as
29 detailed hereinafter. The term secured is intended in
30 this application to mean both the physical securing of
31 the substrate to the anode electrode and more impor-
32 tantly the electrical contacting of the conducting
33 coating surface to the anode electrode. In this manner
34 the coating surface is maintained at the approximate

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1 electrical potential of the anode electrode. The anode
2 electrode is either electrically grounded or supplied
3 with a positive or negative bias of approximately ± 50
4 volts. The sputtering system is further adapted to
5 provide for controlled temperature heating of the
6 substrates. The deposition temperature as recited
7 hereinafter is measured by a thermocouple embedded in
8 the anode electrode.

9 It is to be recognized that the temperatures
10 recited hereinafter are measured accordingly and the
11 actual temperature of the depositing film may differ.

12 The sputtering system is evacuated to a base
13 pressure of about 1×10^{-7} Torr by conventional
14 mechanical and turbomolecular pumping means. An
15 N-layer of hydrogenated microcrystalline silicon, 12,
16 is sputter deposited by first heating substrate to a
17 monitored temperature ranging from about 200°C to
18 about 400°C. A sputtering target comprising a poly-c-
19 crystalline undoped silicon disc about 5" in diameter
20 is secured to the cathode electrode being located
21 about 4.5 cm from the substrate platform (anode elec-
22 trode). Consistent with the condition $H_2/Ar \gg 1$ and
23 total pressure ≥ 20 mTorr, as described above, the
24 sputtering atmosphere comprises a partial pressure of
25 hydrogen ranging from about 20 mTorr to about 80 mTorr
26 and argon ranging from about 3 mTorr to about 10
27 mTorr. For the best microcrystalline material, a pre-
28 ferred combination of parameters should be $H_2/Ar \geq 10$
29 and $H_2 + Ar \geq 40$ mTorr. To dope the hydrogenated
30 microcrystalline silicon layer N an amount of phos-
31 phine (PH_3) is added to the partial pressures of hy-
32 drogen and argon. In one embodiment, the argon source
33 contains 0.2 - 1 atomic % of phosphine. The sputtering
34 is accomplished at an RF power of about 100 to 200

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1 watts resulting in an induced DC bias of about -800 to
2 -2000 volts relative to the electrically grounded
3 substrate platform (anode). The deposition rate of the
4 films depends on the relative amounts of H₂ to Ar in
5 the discharge. These conditions lead to deposition
6 rates between 10 to 40 Å/sec. These lower deposition
7 rates of the microcrystalline material as compared to
8 amorphous material are caused by the higher concentra-
9 tion of H₂ which leads to the etching of the deposited
10 film and thus competes with the deposition process of
11 silicon. The sputtered deposition continues for a time
12 ranging from a minimum of 2.5 min. to about 10 mins.
13 resulting in a thickness of N-layer, 12, ranging from
14 about 100 angstroms to about 400 angstroms. Alterna-
15 tively, the N layer can be produced in a graded form
16 extending 500 to 1000 Å. This can be accomplished by
17 progressively reducing the amount of PH₃ in the disch-
18 arge. The substrate heating described heretofore con-
19 tinues throughout the deposition to maintain the moni-
20 tored substrate temperature within the indicated
21 range. This results in a proper level of hydrogenation
22 of the depositing microcrystalline silicon which was
23 found to be about 3-4% by unfrared spectroscopy.

24 An intrinsic layer of hydrogenated silicon
25 14 is sputter deposited from an undoped silicon target
26 in an atmosphere containing pure argon and hydrogen.
27 This layer 14 is amorphous. The sputtering atmosphere
28 for depositing the intrinsic layer ranges from about 3
29 mTorr to about 15 mTorr of pure argon and from about
30 0.3 mTorr to about 1.5 mTorr of hydrogen. The RF power
31 conditions, cathode and anode configuration, and sub-
32 strate temperature are substantially identical to that
33 described for the sputter deposition of the N-layer.
34 Under these conditions, a layer of intrinsic amorphous

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1 silicon ranging from about 0.2 microns to about 1.5
2 microns in thickness is deposited at a rate ranging
3 from 60A/min to 1000A/min.

4 A P-doped layer of hydrogenated microcrys-
5 talline silicon 16 is sputtered deposited from an
6 atmosphere of argon, hydrogen and diborane. Consistent
7 with the condition $H_2/Ar >> 1$ and total pressure > 20
8 mTorr, as described above, a sputtering atmosphere
9 comprising argon and hydrogen having partial pressures
10 ranging from about 3 mTorr to about 10 mTorr and about
11 20 mTorr to about 80 mTorr respectively, includes a
12 level of diborane dopant sufficient to dope the micro-
13 crystalline silicon P-type. For the best microcrys-
14 talline material, a preferred combination of param-
15 eters should be $H_2/Ar \geq 10$ and $H_2 + Ar \geq 40$ mTorr. In
16 one embodiment, the argon source contains about 0.2 to
17 1 atomic % of diborane (B_2H_6). The sputtering power
18 conditions, monitored substrate temperature ranges,
19 and configuration of the anode and cathode electrodes
20 are substantially identical to those described for the
21 deposition of the N and I layers. The deposition rate
22 of the film depends on the relative amounts of H and
23 Ar in the discharge. These conditions lead to deposi-
24 tion rates of 10A/min to 40A/min. The thickness of the
25 p-layer, as compared to the thickness of the intrinsic
26 and N-doped layers is smaller, ranging from about 80
27 to about 150 angstroms. As presently understood, the
28 p-layer functions to form a potential barrier with the
29 I-layer. The P and N layers fabricated according to
30 the descriptions given above were found by X-ray and
31 Raman spectroscopy to be partially crystallized with
32 crystallite size of 50-60A. Furthermore, the index of
33 refraction of these P and N layers in the visible
34 spectral region are about 3.0 while that of the amor-
35 phous silicon is about 4.0. The P and N layers were

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1 also found to be about one half an order of magnitude
2 less absorbing to visible light than the corresponding
3 amorphous layers. In addition, they have conductivi-
4 ties between 1 and $10 \text{ } (\Omega\text{cm})^{-1}$ while the corresponding
5 amorphous P and N layers have conductivities of 10^{-2}
6 to $10^{-3} \text{ } (\Omega\text{cm})^{-1}$. A current collection electrode 18,
7 comprises an electroconductive material which is semi-
8 transparent in the spectral region ranging from about
9 3,500 angstroms to about 7,000 angstroms, which con-
10 stitutes the principal absorption region of the under-
11 lying amorphous silicon film layers. Further, elec-
12 trode 18 must form a substantially ohmic contact to
13 the contiguous P-doped microcrystalline silicon. In
14 one embodiment, electrode 18 may comprise a semi-
15 transparent conductive oxide such as indium tin oxide,
16 tin oxide or cadmium stannate. In such an embodiment,
17 the thickness of the conductive oxide may be tailored
18 to provide an anti-reflection coating to the underly-
19 ing amorphous silicon surface. These conductive oxides
20 are deposited by RF sputtering from corresponding
21 targets. It is desirable that the oxide be deposited
22 on the solar cell at temperatures between 250 and
23 300°C to anneal any induced sputtering damage on the
24 solar cell and to improve the sheet resistance which
25 was found to be about $50\Omega/\text{sq}$. The index of refraction of
26 these oxides is about 2 to 2.2. Therefore, the index
27 of refraction of the P and N layers of about 3 is an
28 intermediate value between that of the oxide and that
29 of the I layers. This gradual transition of the in-
30 dices of refraction is desirable for better collection
31 of light. In an alternative embodiment, electrode 18
32 may comprise a relatively thin metallic layer, also
33 being semitransparent and forming an ohmic contact to
34 P-doped microcrystalline silicon. An example is plat-
35 inum.

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1 To further assist in the collection of
2 current generated by the photovoltaic device, a grid
3 electrode 20 may be patterned on the surface of elec-
4 trode 18. The electroconductive grid, generally con-
5 figured to minimize the area of coverage and concur-
6 rently minimize the series resistance of the photo-
7 voltaic cell, may be constructed by several alternative
8 techniques well known in the art.

9 Those skilled in the art recognize that the
10 use of a glass or other similarly transparent sub-
11 strate 10, having an transparent electroconductive
12 layer 11 (e.g. ITO or SnO₂), permits illumination of
13 the device through the substrate. Furthermore, the
14 deposition sequence of P and N layers may be reversed
15 to deposit a layer of P microcrystalline silicon onto
16 an ITO coated substrate, having the intrinsic and N
17 layers deposited thereupon.

18 It is to be recognized that the several
19 layers comprising the photovoltaic device described
20 heretofore, may be accomplished by sputtering tech-
21 niques facilitating the construction of this device in
22 a singular vacuum sputtering unit and in a singular
23 vacuum pump down. It should further be recognized that
24 the sputtering techniques used in the construction of
25 a photovoltaic device of the present invention result
26 in enhanced physical integrity and adherance of the
27 deposited films. The method manifests in an ability to
28 sputter deposit a layer of semi-transparent conductive
29 oxides such as indium tin oxide onto a relatively thin
30 P doped layer, 16, without deteriorating the junction
31 forming characteristics of the underlying silicon
32 layers. Essentially the cell can be illuminated either

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1 from the substrate side or the side opposite the sub-
2 strate because of the superior properties of the
3 sputtered microcrystalline N and P layers.

4 EXAMPLE

5 Figure 2 shows the I-V characteristics of a
6 sputtered amorphous silicon PIN solar cell structures
7 employing microcrystalline P and N layers. Note that
8 the short circuit current in this device is 13mA/cm^2
9 and the open circuit voltage is 0.86 volts. The sub-
10 strate in this structure is mirror polished stainless
11 steel. This substrate was ultrasonically cleaned and
12 degreased before it was fastened to the anode elec-
13 trode of the previously described diode sputtering
14 unit. The vacuum chamber was evacuated to a base pres-
15 sure of 1×10^{-7} Torr and the substrate was heated to
16 325°C. The three active layers of the device were
17 deposited under the conditions and order described
18 below:

19 The partially crystallized N-layer was depo-
20 sited in an atmosphere of 40 mTorr of $\text{H}_2 + \text{Ar} + \text{PH}_3$.
21 The partial pressures of these gases were 36 mTorr of
22 hydrogen and 4 mTorr of argon. The phosphine was con-
23 tained in the cylinder of argon at a concentration of
24 0.2 atomic %. Therefore, during the deposition of this
25 layer the ratio of H_2/Ar was much larger than one and
26 the total pressure was larger than 20 mTorr. Both of
27 these conditions were found to be necessary for the
28 deposition of partially crystallized N-layer. The
29 polycrystalline undoped silicon target, 5" in di-
30 ameter, was supplied with an RF power of 100 watts
31 leading to a target voltage of -1200 volts. The depo-
32 sition lasted for 6 min. leading to a film of approxi-

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1 mately 200 Å thick. As mentioned earlier this film has
2 a conductivity of about $10 (\Omega \text{ cm})^{-1}$ and is far more
3 transparent than the corresponding amorphous N-layer.

4 At this point the substrate with the N-layer
5 was transferred in another clean chamber for the depo-
6 sition of the intrinsic I-layer. This layer was depo-
7 sited in an atmosphere of 5 mTorr of Ar + H₂. The
8 hydrogen content in this discharge was approximately
9 18% of the argon content. The 5" polycrystalline
10 undoped silicon target was supplied with an RF power
11 of 80 watts leading to a bias voltage of -1000 volts.
12 The deposition for this layer lasted 60 min. leading
13 to an I-layer about 4000 Å thick. The substrate
14 temperature during this deposition was maintained at
15 325°C.

16 The partially crystallized P-layer was depo-
17 sited next in an atmosphere of 40 mTorr of H₂ + Ar +
18 B₂H₆. The partial pressures of these gases were 36
19 mTorr of hydrogen and 4 mTorr of argon. The B₂H₆ was
20 contained in the cylinder of argon at a concentration
21 of 0.2 atomic %. Under these conditions the P-layer is
22 partially crystallized having a conductivity of about
23 $2 (\Omega \text{ cm})^{-1}$ and high transparency. The polycrystalline
24 undoped silicon target, 5" in diameter, was supplied
25 with an RF power of 60 watts, leading to a target
26 voltage of -800 volts. The deposition of this layer
27 lasted for 3 min., leading to a P-layer of 100 Å
28 thickness.

29 At this point the substrate with the three
30 active layers (N,I,P) was moved to another sputtering
31 chamber for the deposition of an ITO (Indium Tin
32 Oxide) layer on the top of the P-layer. This layer was
33 deposited from an ITO target in an atmosphere of

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1 argon. The target voltage during this deposition was
2 maintained at -600 volts and the thickness of this
3 layer was chosen to be 600 to 700 Å. A metal grid
4 made of silver was deposited on the top of the ITO.

CLAIMS:

1 1. A method for producing an amorphous silicon
2 PIN or NIP semi-conductor device having partially crystal-
3 lized (microcrystalline) P and N-layers comprising:

4 providing a substrate having at least a surface
5 region comprising an electroconductive material which
6 forms an ohmic contact to doped microcrystalline sili-
7 con;

8 reactively sputtering a layer of microcrystal-
9 line silicon doped with one type of charge carrier
10 onto at least said surface region of the substrate;

11 reactively sputtering a layer of amorphous
12 intrinsic, I, silicon onto said layer of silicon doped
13 with said one type of charge carrier;

14 reactively sputtering a layer of microcrystal-
15 line silicon doped with the other type of charge
16 carrier onto said I layer;

17 sputtering an electroconductive material onto at
18 least a region of said layer of microcrystalline sili-
19 con doped with said other type of charge carrier which
20 material forms an ohmic contact thereto.

21 2. A method according to claim 1 wherein said one type
22 of charge carrier is N type and said other type of
23 charge carrier is P type.

24 3. A method according to claim 1 wherein said one type
25 of charge carrier is P type and said other type of
26 charge carrier is N type.

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1 4. A method according to either of claims 2 and 3 wherein said reactive sputtering of N doped microcrystalline silicon comprises sputtering microcrystalline silicon in partial pressures of hydrogen, ranging from about 20 mTorr to about 80 mTorr, and argon ranging from about 3 mTorr to about 10 mTorr, said partial pressure of argon including about 0.2 to 1 atomic % of phosphine (PH₃).

9 5. A method according to claim 4 wherein said N-doped microcrystalline silicon is sputtered from an undoped polycrystalline silicon target.

12 6. A method according to any one of the preceding claims wherein an RF sputtering power of about 100 watts to 200 watts is coupled to the plasma, resulting in a target dc voltage of about -800 volts to about -2000 volts.

16 7. A method according to claim 6 wherein said substrates are maintained at a temperature ranging from about 200°C to about 400°C.

19 8. A method according to any one of the preceding claims wherein said reactive sputtering of the intrinsic, I, layer of silicon comprises sputtering silicon in partial pressures of hydrogen, ranging from about 0.3 mTorr to about 1.5 mTorr, and argon, ranging from about 3 mTorr to about 15 mTorr.

25 9. A method according to any one of claims 2 to 8 wherein said reactive sputtering of the P layer of microcrystalline silicon comprises sputtering microcrystalline silicon in partial pressures of hydrogen, ranging from about 20 mTorr to about 80 mTorr, and argon, ranging from about 3 mTorr to about 10 mTorr, said argon containing about 0.2 to 1 atomic % of diborane, B₂H₆.

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10. A method according to any one of the preceding claims wherein said electroconductive material, sputtered onto said P-doped microcrystalline silicon is a thin film of material selected from indium tin oxide, tin oxide and cadmium stannate.

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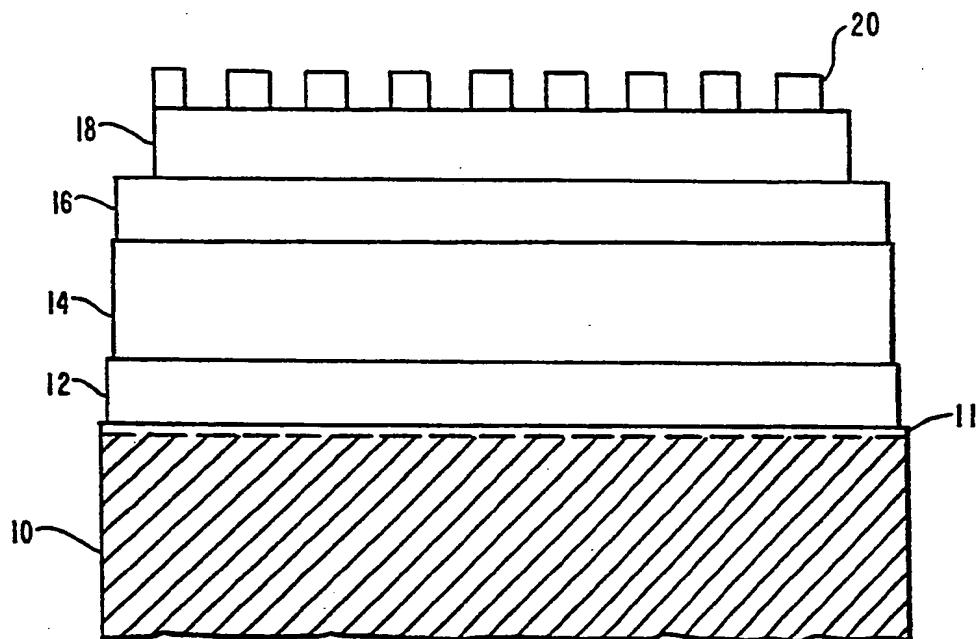


FIG. I

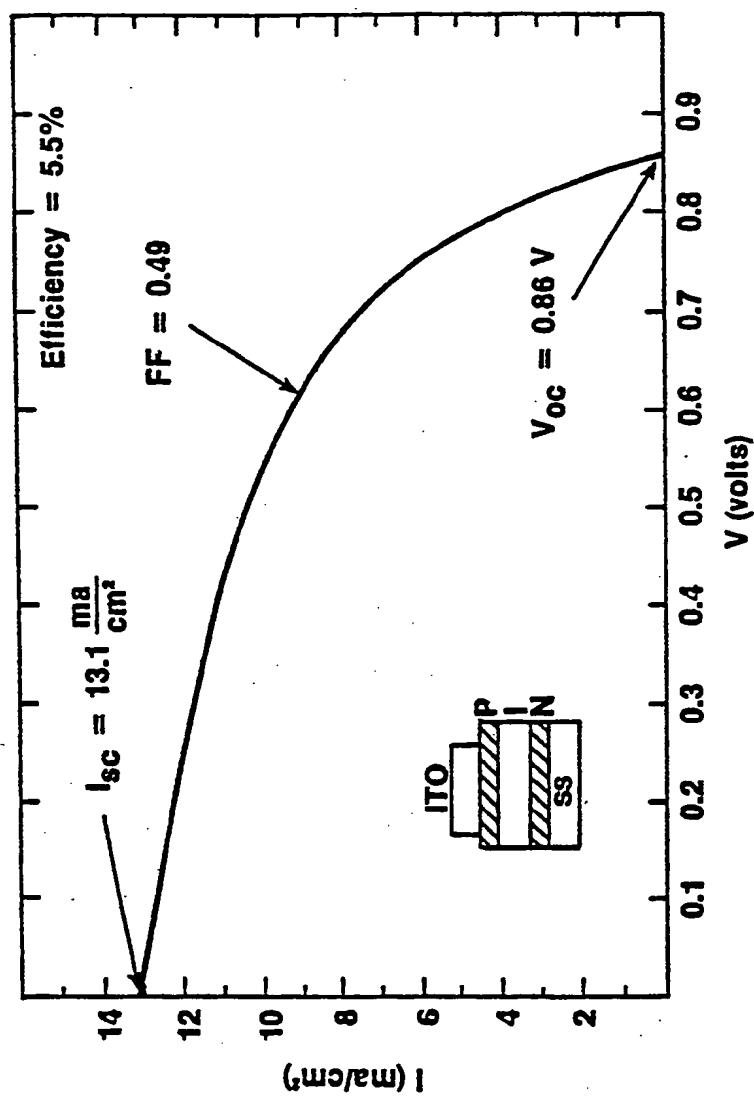


FIG. 2

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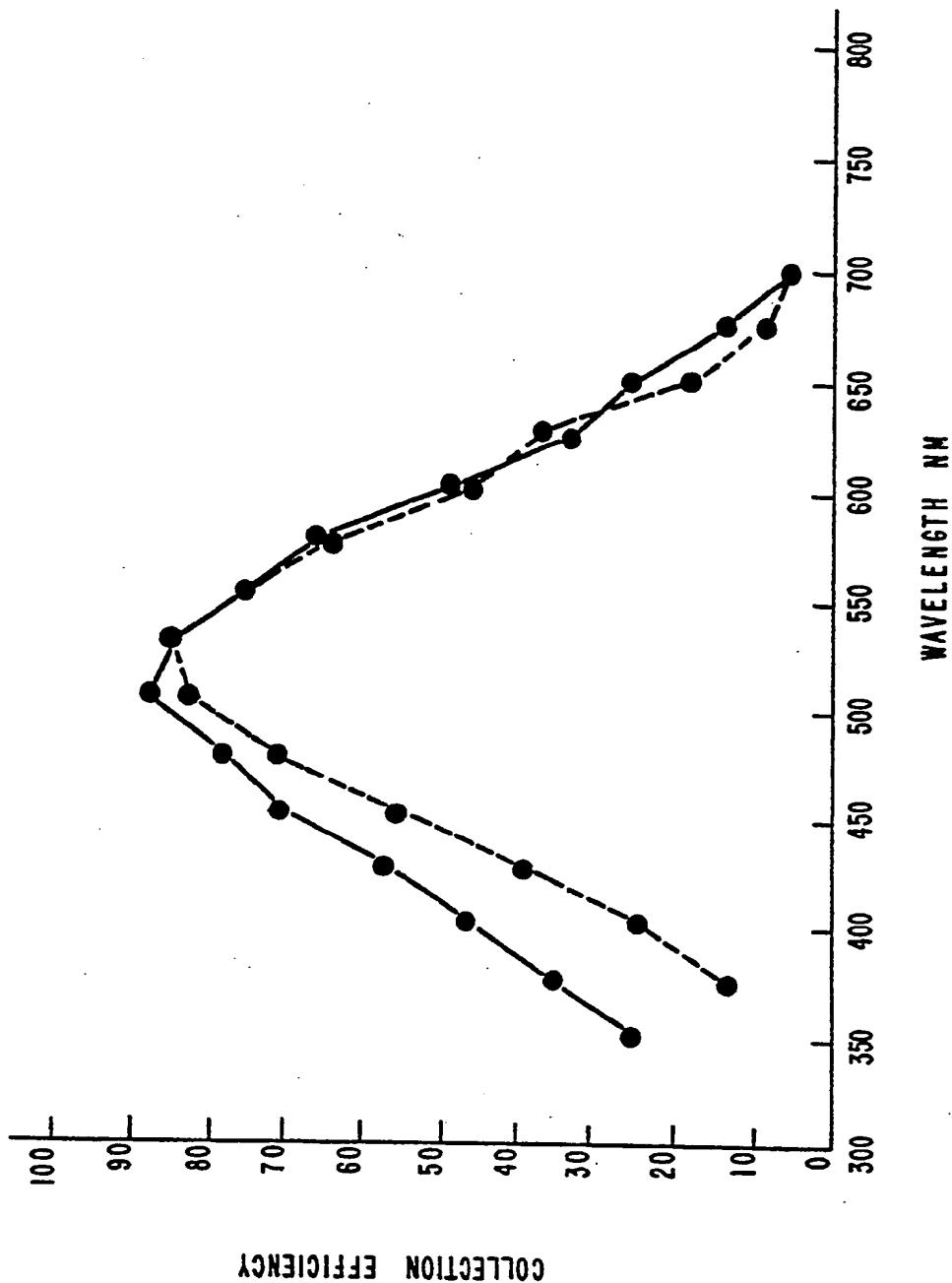


FIG. 3



European Patent
Office

EUROPEAN SEARCH REPORT

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Application number

EP 84 30 6505

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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Y	--- EP-A-0 060 363 (EXXON) * Claims 1-3, 6, 7 *	1-3, 7 8, 10	
A	--- WO-A-8 101 914 (J. GIBBONS) * Claim 1 *	1-3	
Y	--- IBM TECHNICAL DISCLOSURE BULLETIN vol. 19, no. 12, May 1977, New York, USA; H. BRODSKY et al. "Doping of sputtered amorphous semiconductors" * Pages 4802-4803 *	4, 5, 8, 9	TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
A	--- JAPANESE JOURNAL OF APPLIED PHYSICS vol. 21, no. 4, part 2, April 1982, Tokyo, JP; M. NODA et al. "Microstructures and hydrogen bonding environments of sputter-deposited a-Si:H films" * Pages L 195-197 *	---	H 01 L 21/203 H 01 L 31/00
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The present search report has been drawn up for all claims			
Place of search BERLIN	Date of completion of the search 18-12-1984	Examiner ROTHER A H J	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone	T : theory or principle underlying the invention		
Y : particularly relevant if combined with another document of the same category	E : earlier patent document, but published on, after the filing date		
A : technological background	D : document cited in the application		
O : non-written disclosure	L : document cited for other reasons		
P : intermediate document	& : member of the same patent family, corresponding document		



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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim			
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TECHNICAL FIELDS SEARCHED (Int. Cl.4)					
The present search report has been drawn up for all claims					
Place of search BERLIN	Date of completion of the search 18-12-1984	Examiner ROTHER A H J			
CATEGORY OF CITED DOCUMENTS <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document </td><td style="width: 50%; vertical-align: top;"> T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document </td></tr> </table>				X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document	T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document
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